ANNUAL REPORT ON FY97 ONR SPONSORED RESEARCH

OCEAN DYNAMICS

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LONG-TERM GOAL

To gain a more complete understanding of ocean dynamical processes, particularly at fine-scale, through intercomparison of high, mid- and low-latitude observations, both near the sea surface, in the main thermocline, and near the sea floor.

OBJECTIVES

To compare fine and internal wave scale measurements from equatorial, mid-latitude and Arctic observations. To quantify the relationship between fine-scale background conditions and the occurrence of microscale breaking.

APPROACH

Progress is effected through a steady-state cycle of instrument development, field observation and data analysis. The primary instruments employed include Doppler sonar and profiling CTD's. Generically, our instruments produce information which is quasi-continuous in space and time. Measurements typically span two decades in the wavenumber domain. This broad band space-time coverage enables the investigation of interactions which span space and time scales.

WORK COMPLETED

A multi-year study of shear, strain and Richardson number statistics has culminated in two publications in Journal of Physical Oceanography. The purely statistical approach was employed because, at fine-scale, many physically important quantities, such as the Vaisala frequency (inverse strain) are significantly non-Gaussian. A power spectrum provides an incomplete description of the field.

A focus of the effort was on a general model for ocean mixing. Bretherton, 1969, and Garrett and Munk, 1972, laid the groundwork for statistical mixing models. However, both efforts produced results which were extremely sensitive to the assumed levels of rms shear. Recent observational work by Gregg (1989) has suggested a more moderate dependence of mixing on shear variance ($\varepsilon \sim \langle S^2 \rangle^2$). Trading realism for simplicity, the GM type mixing formalism was revisited using correct pdf's of Richardson number and a more modern version of the internal wave spectrum (similar to Munk, 1981). With these advances, it proved straightforward to reconcile the logically pristine mixing formalism of GM 72 with the more recent observations.

RESULTS

Statistical predictions of mixing rates have been made in advance of an understanding of the detailed mechanisms involved. Numerous theoretical models, including the notable work of Henyey et at.(1986), have been posited, in the absence of quality observations of the sequence of events which lead to mixing. As a result of the statistical work, we are motivated to merge shear and density observations to obtain a phenomenological picture of ocean mixing. Mixing "events" are identified as density inversions of vertical scale 2 m and greater, as determined by a profiling CTD.

The study, based on 12 days of MBL data, resulted in several surprises. While there is some correspondence between mixing and the occurrence of low Richardson number, the strongest correspondence is with the occurrence of large vertical strain, $\frac{\partial \eta}{\partial z}$, and large rate of change of strain, $\frac{\partial w}{\partial z}$. These signals are associated with the propagation of small scale highly non-linear waves, which can be observed if the density field is examined in detail.

IMPACT/APPLICATION

We now know that small scale internal wave dynamics is intimately involved in determining when and where overturning occurs in the sea, and that Kelvin-Helmholtz instability is not the primary mixing mechanism. This knowledge can be applied in the analysis of existing data and in the prediction of other potential ocean mixing sites.

TRANSITIONS

The experimental capabilities developed in the course of this work are being applied in proposed investigations of coastal mixing, under ONR and NSF sponsorship. Sector-scan Doppler sonars, developed as an aspect of this work have been transitional for use in the near-shore experiments taking place at DUCK, N.C. Dr. Jerome Smith has lead in this effort.

RELATED PROJECTS

The Marine Boundary Layer observations benefit greatly from the technical legacy of preceding upper ocean programs such as SWAPP, LEADEX and TOGA COARE. In these experiments the instruments and techniques were developed which made MBL possible. Also, the Naval Sea Systems Command provided for a much needed overhaul of the Research Platform FLIP. The renovated FLIP performed quite well in support of MBL.

In turn, the instrument technology developed for MBL will be used in coming ONR research programs. SANDY DUCK, SHEBA and other programs will make use of the MBL systems.

It is anticipated that the aspects of MBL which are unique geographically, such as the tidal and mixing observations of MBL I, can be used to plan a coming series of ONR experiments which hope to quantify the difference between the coastal ocean and the deep sea, at small scales.

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